Using Soil CEC and Cation Ratios on Your Farm

AGVISE Laboratories tests over 400,000 soil samples each year. We test thousands of samples for CEC and calculate the base saturation for many customers. AGVISE has 40 years' experience in soil analysis and participates in the North American Proficiency Testing program (over 140 soil testing labs from across North America participate in NAPT).

Why Is CEC Important?

CEC (Cation Exchange Capacity) is very closely related to soil texture and is an important property of the soils on your farm. Soil particles have a negative charge, which allows the soil to hold cations. The cations of interest are potassium (K+), calcium (Ca++), magnesium (Mg+) and sodium (Na+). These cations have a positive charge and are held to the soil particles which have a negative charge, like a magnet would attract iron nails. This attraction is a good thing because it prevents the cations from being leached away with excessive rainfall. Soil organic matter also has a negative charge and holds some cations and is small part of the CEC of the soil.

The CEC of a soil is a permanent characteristic and is directly related to soil texture. The higher the CEC of your soil, the higher the soil clay content. If you know the CEC of your soil from a soil test, you have a good idea what the soil texture is. In general, a low CEC soil has a coarse texture like loamy sand and a high CEC soil has a fine texture such as a clay loam (see the table below). This is important information when deciding things like which fields can have fall nitrogen applied to them and which fields should have nitrogen applied only in the spring.

CEC (Cation Exchange Capacity) and Soil Texture

Soil Texture	CEC (m.e./100gm)
Clay Loam	20-30+
Silt Loam	15-20
Loam	12-15
Sandy Loam	10-12
Loamy fine Sand	less than 10

What about Cation Ratios like Calcium to Magnesium?

Soil testing laboratories use the ppm test level of each of the cations (potassium, calcium, magnesium and sodium and hydrogen on acid soils) to calculate the CEC. The laboratory also

calculates what percentage of the total cations is made up by each individual cation. For example, Calcium might make up 65% of the total cations while potassium, magnesium and sodium making up the other 35% of the cations. In the 1930's and 1940's there was some research that suggested an "ideal soil" needed to have a specific percentage of each cation to achieve high yields. Later research in 1950's, suggested that there was a wider "range" each cation could be in and still achieve high yields. By the 1970's, with much better laboratory instrumentation, research showed that the percent of each cation or the ratio of one cation to the other was not important for achieving high yields. In fact the research showed that the ratio of one cation could vary widely in high and low yielding situations (see table below). It is obvious from this research the ratio of one cation to another was not the reason for low or high yields. What was important was that the soil had a sufficient amount of each of the nutrients.

Does Calcium Magnesium Ratio Affect Corn and Soybean Yield?

Yield University Research Plots	Corn	Soybeans
5 Highest Yielding Sites	6 to 27 Ca/Mg Ratio	6 to 22 Ca/Mg Ratio
5 Lowest Yielding Sites	6 to 22 Ca/Mg Ratio	7 to 22 Ca/Mg Ratio

Ohio State University

Does Calcium Magnesium Ratio Affect Alfalfa Yield?

Calcium/ Magnesium Ratio	Yield (Dry Matter)
2.3 Calcium/Magnesium	3.3 tons/acre
4.8 Calcium/Magnesium	3.4 tons/acre
8.4 Calcium/Magnesium	3.2 tons/acre

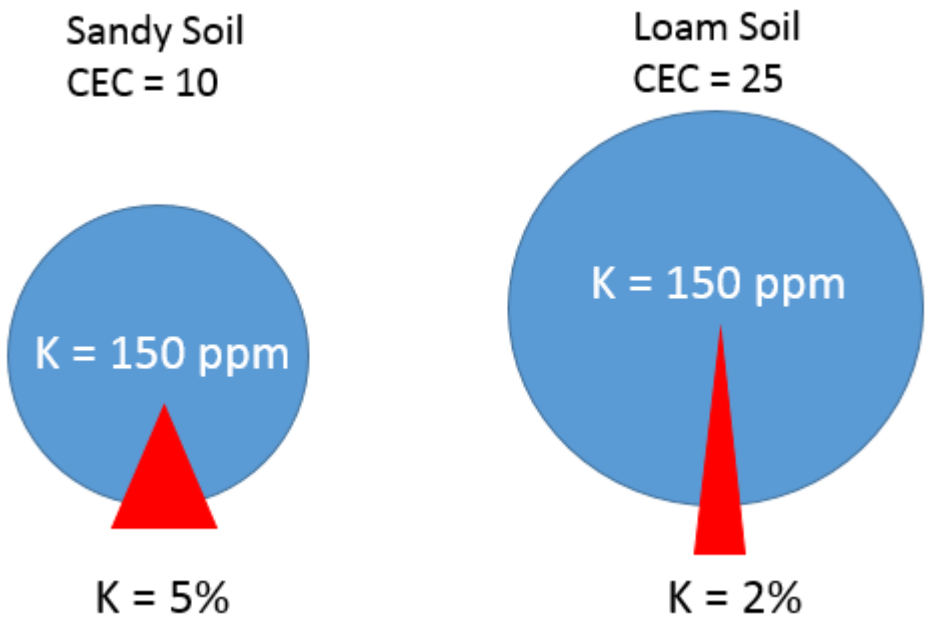
University of Wisconsin

Many research studies from the 80's to the present have confirmed the research from the 70's. The most important thing is to have a sufficient level of each cation in the soil, not the ratio of one to the other. The critical level for these cations is shown below.

Cation	**Critical Soil Level**
Potassium	150 ppm
Magnesium	100 ppm
Calcium	Lime requirement by buffer pH determination

Does Potassium (K) Need to be a Certain % of the Total Cations?

In the western U.S. and Canada, many soils have soil pH higher than 7.3, high potassium test (> 160 ppm) and a high CEC. On these high pH soils, the calcium and magnesium levels are usually high as well. Calcium can make up more than 80% of all the cations held on these soils based on the calculation from the routine soil test. The remaining 20% of the cations is made up of potassium, magnesium and sodium. It is very common for potassium to only be 1-3% of the total cations held on a high pH soil. Some people would tell you that more potassium fertilizer is needed to achieve high yields in this situation because the percent potassium is too low compared to the total cations. Research has shown many times that adding extra potassium fertilizer to increase the percent potassium held on the CEC does not increase yields as long as the potassium test level is greater than 150 ppm. The CEC of these soils is so high that even though a small percentage of the cations are potassium, there is still plenty of potassium to achieve high yields as long as the K soil test level is higher than 150 ppm. In other words, if you have a low CEC soil (small pie below) and a high CEC soil (big pie), the potassium the crop gets from a narrow slice of the big pie (high CEC loam soil) is the same the crop will get from a big slice of a smaller pie (low CEC sandy soil). The percentage is not important, what is important is that the K test level is over 150 ppm in each of these soils.



If the potassium sol test is lower than 150 ppm, then you will need to apply potassium fertilizer to achieve high yields. The potassium fertilizer is applied to take care of crop K needs, not to try and change the cation ratio in the soil. It does not matter if the % K (potassium) is lower than some “idea range” based on research from the 1930’s. It is important to have the soil test level for each cation, like potassium test higher than the critical level established by university and industry research (about 150 ppm).

How much K_2O is Needed to Increase my K Percentage?

Research has shown that it takes about 8 lbs of K_2O per acre to increase the soil K test 1ppm. If you were one of the people who still follow the cation ratio information from the 1930's, the amount of potash fertilizer needed to increase the K percentage to 5% on a loam or heavy clay soil would be very high. The table below illustrates the amount of potassium fertilizer you would need to apply to build the soil K to 5% of the total cations. You can see the cost to apply this much K fertilizer is very high (for no increase in crop yield). Years of research has shown that yield responses to K fertilizer on soil testing over 150 to 200 ppm is limited to a starter fertilizer application. The table below shows the cost would exceed over $1,000 per acre to build the K soil test level high enough so that K would be 5% of the total cations. Even if you decided to apply this very high rate of K fertilizer, research has shown you will not get a yield response.

CEC	Soil Test (ppm)	% K	Desired K Level	Desired K Level in ppm	lbs K_2O Needed To Achieve 5.0% K	Lbs/acre 0-0-60	Building Cost at $475/ton
30	150	1.3%	5.0%	580	3440	5733	$1,362
20	150	1.9%	5.0%	390	1920	3200	$760
10	150	3.8%	5.0%	195	360	600	$143

Important Things To Remember

1. Soil CEC (Cation Exchange Capacity) is important and is directly related to soil texture. Knowing the CEC is very important for decisions like nitrogen management.
2. The ratio of one cation to the other is not important as long as the soil test level for each cation is above the critical soil level needed for high crop yield.
3. Soil testing will show you if the soil test level for each cation is above the critical level Potassium 150 ppm, Magnesium 100 ppm and Calcium – lime requirement by buffer pH determination.
4. Applying extra potassium fertilizer to try and change cation ratios in the soil is expensive and does not increase yield. If you decided to apply 50 lb/a of potash fertilizer (0-0-60) that you didn't need it will cost you about $20.00/acre. Why spend money on extra potassium fertilizer that will not increase yield?

Please contact your AGVISE Soil Scientist or Agronomists if you have any questions.

Soil Scientist – John Lee: 701-587-6010, cell 701-739-0521
Soil Scientist – Bob Deutsch: 701-587-6010
Agronomist – Richard Jenny: 320-843-4109, cell 320-815-4100
Agronomist – Cindy Evenson: 320-843-4109
Soil Scientist – Larry Wikoff: 701-587-6010